



FAA-E-2678/6  
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## DEPARTMENT OF TRANSPORTATION FEDERAL AVIATION ADMINISTRATION SPECIFICATION

### VOR/VORTAC EQUIPMENT REPLACEMENT AND FACILITY MODERNIZATION PART 6 - DME/TACAN TRANSPONDER EQUIPMENT

#### 6-1 SCOPE AND CLASSIFICATION

6-1.1 Scope of Part 6.- This Part 6 is one of a group of specification documents under the basic heading VOR/VORTAC Equipment Replacement and Modernization, each of which carries the basic number FAA-E-2678 with a slant line and number corresponding to the Part number. This Part 6 covers requirements for DME/TACAN Transponder Equipment to be furnished as part of sets of equipment as defined in Part 1 of this specification (FAA-E-2678/1).

6-1.2 Limitations of Part 6.- This Part 6 does not completely define the requirements for physical and electrical interface with other equipment elements covered under other parts of the specification these being the responsibility of the designer of the complete system. Additionally, certain requirements are defined only through reference to other parts of the specification.

6-1.3 Classification.- Two types and two configurations of equipment are covered by this specification.

6-1.3.1 Types.- The two types of equipment are DME Transponder and TACAN Transponder.

6-1.3.2 Configuration.- The two configurations applicable to each Type are Single and Dual.

## 6-2 APPLICABLE DOCUMENTS

### 6-2.1 FAA Specifications.-

FAA-E-2678/1	Part 1	General Requirements
FAA-E-2678/2	Part 2	Battery Charger Power Supply (BCPS)
FAA-E-2678/3	Part 3	Facility Central Processing Unit (FCPU)
FAA-E-2678/4	Part 4	VOR Transmitter Equipment
FAA-E-2678/7	Part 7	DME/TACAN Monitor Equipment
FAA-E-2678/8	Part 8	Facility Control and Transfer Equipment (FCT)

## 6-3 REQUIREMENTS

6-3.1 Equipment to be furnished by the contractor.- Each set of equipment, shall be complete and in accordance with all specification requirements and shall include the items tabulated below. Each set of equipment shall be completely wired and ready for operation upon connections of power, external control cables, external antenna cable, and when interconnected with other equipment units comprising a set of ground station equipment as defined in Paragraphs 1-3.1.3 through 1-3.1.6 of Part 1 of this specification. Each set of equipment shall be tuned and adjusted for operation on a channel assigned in accordance with the provisions contained in the contract schedule prior to shipment (See Table I of Part 1 for channel frequencies and pairings.) Instruction books in accordance with FAA-D-2494/1 and FAA-D 2494/2 shall be furnished in quantities specified in the contract schedule.

6-3.1.1 Single DME.- Each single DME shall consist of the components described in paragraphs 6-3.4 through 6-3.4.7.1 less 6-3.4.6 (Reference Group Generator Module).

6-3.1.2 Dual DME.- Each dual DME shall consist of two separate and identical equipments as defined in 6-3.1.1 above.

6-3.1.3 Single TACAN.- Each single TACAN shall consist of the components described in paragraphs 6-3.3.1 through 6-3.4.7.1 and a separate TACAN Final Amplifier (6-3.4.7.2).

6-3.1.4 Dual TACAN.- Each dual TACAN shall consist of two separate and identical equipments as defined in 6-3.1.3 above (except that only one TACAN Final Amplifier (6-3.4.7.2) shall be required)

6-3.2 Definitions.- (See also paragraph 1-3.2 et seq of Part 1).

6-3.2.1 Interrogation signal - The term "interrogation signal", as used herein, denotes a signal having the characteristics identified in the subparagraphs below:

6-3.2.1.1 Radio frequency.- The center radio frequency of the interrogation signal is within 0.01% of the interrogation frequency listed in Table I of Part 1 for the channel in use.

6-3.2.1.2 Radio frequency pulse spectrum.- The rf spectrum of the interrogation signal is such that not less than 87.5% of the energy in each pulse is within a 500 KHz band centered on the channel interrogation signal frequency and in which each additional lobe of the spectrum is of lesser amplitude than the adjacent lobe nearer the channel frequency.

6-3.2.1.3 RF pulse shape.- The rf envelope of each pulse, as detected by a linear detector, has a shape falling within the limits set forth in the subparagraphs hereto.

6-3.2.1.3.1 Pulse rise time.- The pulse rise time from the 10 percent point to the 90 percent point of the maximum voltage amplitude on the leading edge of the pulse is not less than 0.2 us (microsecond) nor more than 3.0 us.

6-3.2.1.3.2 Pulse top.- The instantaneous amplitude of the pulse does not, at any instant between the point on the leading edge which is 95% of the maximum voltage amplitude and the point on the trailing edge which is 95% of the maximum voltage amplitude, fall below a value which is 95% of the maximum voltage amplitude.

6-3.2.1.3.3 Pulse duration.- The pulse duration, from the 50 percent point of the maximum voltage amplitude on the leading edge of the pulse to the 50 percent point of the maximum voltage amplitude on the trailing edge of the pulse, is  $3.5 \pm 0.5$  us.

6-3.2.1.3.4 Pulse decay time.- The pulse decay time, from the 90 percent point to the 10 percent point of the maximum voltage amplitude on the trailing edge of the pulse is not less than 0.2 us nor greater than 3.5us.

6-3.2.1.4 Pulse coding.- Pulses are coded in pairs with a spacing as measured between the 50% maximum voltage amplitude point on the leading edge of the first rf pulse to the corresponding point on the leading edge of the second rf pulse, of (a)  $12.0 \pm 0.5$  us for channel numbers ending in the suffix "X", or (b)  $36.0 \pm 0.5$  us for channel numbers ending in the suffix "Y".

6-3.2.1.5 Interrogation rate.- The pulse pair rate for each interrogation signal is not less than 10 nor more than 150 pulse pairs per second.

6-3.2.2 Not used.

6-3.2.3 Transponder reply delay time.- For the purposes of this specification, reply delay time is defined as the time in microseconds of all delay introduced by circuitry of the transponder equipment in transmitting a pair of reply pulses in response to an interrogation signal. The reply delay time is measured from the 50% maximum voltage amplitude point on the leading edge of the first constituent rf pulse of the interrogation pulse pair to the corresponding point on the first constituent rf pulse of the reply pulse pair. (Note that first pulse timing is involved which will require retention of the time of the 50 percent amplitude point of the leading edge of the first pulse pending decode or pulse spacing validation. The nominal values of reply delays are 50 us for "X" channel and 56 us for "Y" channel).

6-3.2.4 Squitter.- Randomly occurring pulse pairs generated within the transponder as required to maintain a constant total output pulse count (exclusive of azimuth reference pulses in the case of TACAN) of  $2700 \pm 90$  pulse pairs per second. As the number of replies to aircraft interrogations increases, the number of squitter pulses is automatically reduced to maintain the total output pulse count at the specified level.

6-3.2.5 Automatic Gain Reduction (AGR).- A feature of the transponder which automatically reduces the sensitivity of the receiver to limit the number of replies to interrogations to a specified maximum (presently  $2700 \pm 90$  pulses per second).

6-3.2.6 Receiver sensitivity.- That level of interrogation signal as measured at the antenna input terminals of the ground station transponder which results in 70% replies to the interrogation signal. The terms "receiver sensitivity" and "receiver threshold triggering level" are often used interchangeably. (See 6-3.2.7 below.)

6-3.2.7 Receiver threshold triggering level.- (See 6-3.2.6 above.) As used herein refers to the receiver sensitivity in the absence of traffic loading resulting in AGR or reduction in reply efficiency due to echo suppression blanking.

6-3.2.8 Reply efficiency.- The percentage of replies provided by the transponder to an interrogation signal of a given level. The maximum reply efficiency is limited by the number of receiver output pulses (squitter plus replies) and the receiver dead time and additionally (in the case of TACAN) by the priority of transmittal of azimuth reference pulses.

6-3.2.9 Receiver dead-time.- A period of time (nominally 60 u sec) following the decoding of an interrogation pulse pair (and encompassing the time occupied by the transmittal of a reply pulse pair) during which the receiver is prevented from decoding a following interrogation pulse pair.

6-3.2.10 Echo suppression.- A feature of the transponder intended to prevent multiple replies as the result of echoes in the interrogation (air-to-ground) path.

6-3.3 Equipment basic requirements.- (See paragraph 1-3.3 et seq of Part 1).

6-3.3.1 Equipment physical design and packaging.- (See paragraph 1-3.3.1 of Part 1) DME equipment (including monitor(s), Part 7) shall be designed for mounting in a single cabinet. A maximum of two (abutting) cabinets may be utilized for TACAN equipment. Arrangement of units within the cabinet(s) shall facilitate conversion from a single to dual configuration and from a DME system to a TACAN system with a minimum amount of equipment relocation or re-connection.

6-3.3.2 Modular construction.- (See also paragraph 1-3.3.1.3 of Part 1). Conversion from DME to TACAN operation (except for addition of the TACAN Final Amplifier and associated adjustments if required) shall be accomplished solely by the addition of a single plug-in Reference Group Generator module.

6-3.3.3 D.C. Input voltage.- See paragraph 1-3.3.3 of Part 1. The equipment contractor shall establish design center voltages and tolerances in conjunction with his design of the Battery Charger Power Supply (BCPS) of Part 2 of this specification.

6-3.3.4 Stabilization of performance characteristics.- See paragraph 1-3.4.1.3 of Part 1. The equipment contractor shall establish performance requirements for the transponder (as well as for other individual units of the system) as required to meet the overall requirements of paragraph 1-3.4.1.3.

6-3.3.5 Reliability.- See paragraph 1-3.5.1 of Part 1.

6-3.4 Transponder design functional and performance requirements.- The transponder when operated in conjunction with a DME or TACAN antenna (antenna not required to be furnished under this specification) shall:

- (a) produce and radiate north and auxiliary reference burst signals in response to timing pulses provided by the antenna (TACAN only);
- (b) produce and radiate international Morse Code identification signals;
- (c) receive and decode interrogation signals and, in response thereto, radiate a properly coded reply pulse pair after a specific reply delay time; and

- (d) produce and radiate random pulse pairs in addition to those of (c) above, sufficient in number to maintain a total output pulse count (exclusive of TACAN azimuth reference pulses, (a) above) of  $2700 \pm 90$  pulse pairs per second.

The following paragraphs identify requirements for the transponder equipment and associated circuitry.

6-3.4.1 Operating channels.- Transponders shall provide the specified performance on each of the channels and modes (X or Y) listed in Table I of Part I when the proper frequency channel is selected by means of the frequency synthesizer (paragraph 1-3.3.10.3 of Part I). (Except as may be permitted in 6-3.4.1.1 and 6-3.4.1.2 below no other action shall be required to change channels.)

6-3.4.1.1 Broad band operation.- Unless otherwise specified in the contract or request for proposal one single design shall be utilized for each RF device to cover operation on any selected channel.

6-3.4.1.2 RF tuning.- Unless otherwise provided in the contract or request for proposal each RF device shall be capable of operating on any channel assignment within its design range (6-3.4.1.1 above) without the need for retuning. A receiver pre-amplifier (if used) shall be exempt from this requirement.

6-3.4.1.3 Channel frequency accuracy and stability.- See paragraph 1-3.3.10.2 of Part I.

6-3.4.1.4 RF pulse parameters.- RF pulse parameters shall be based on linear detection of the RF envelope(s) of the pulses. Reply pulse spacing and shape shall be as measured at the output of the transmitter, and reply delay shall be measured as defined under 6-3.2.3. (While certain requirements on permitted variation and stability may be contained hereinafter under a specific functional heading most directly associated with the required performance, the stated requirement shall nevertheless apply to the transponder as a whole.)

6-3.4.2 Duplexer.- A duplexer shall be provided to permit simultaneous operation of the receiver and transmitter when connected to the single antenna. The duplexer shall be of the passive type. No adjustment shall be required in order to achieve the performance required throughout the band of frequencies listed in Table I of Part I.

6-3.4.3 Receiver and associated video circuitry.- All performance requirements specified hereinafter which involve interrogation signal(s) shall be met when the signals have any combination of characteristics defined under paragraphs 6-3.2.1 through 6-3.2.1.5 and, unless otherwise indicated, have any value from threshold triggering level to not less than -10 dBm as referenced to the transponder antenna transmission line connector.

6-3.4.3.1 Receiver bandwidth and stability.- The bandwidth of the receiver and the stability thereof shall be such that the threshold sensitivity is not reduced by more than 3 dB when the total receiver drift in either direction is added directly to an interrogation signal frequency deviation of 100 KHz in the opposite direction.

6-3.4.3.2 Receiver decoder.- The decoder shall decode and produce an output pulse from interrogation signal pulse pairs occurring at spacings within the range of:

- (a)  $12 \pm 0.5$  us for channel numbers ending in the suffix "X" or
- (b)  $36 \pm 0.5$  us for channel numbers ending in the suffix "Y".

Decoding of a single pulse shall not occur.

6-3.4.3.3 Receiver dead time.- Each decoded pulse (6-3.4.3.2) shall result in the generation of a dead time interval during which time the transponder shall not reply to any other signals at any and all levels up to -10 dBm. The dead time interval shall be adjustable throughout the range of 50 to 150 us. With the exception of the number of decoded receiver noise pulses permitted under 6-3.4.3.9, dead time shall only be generated by received and decoded interrogation pulse pairs.

6-3.4.3.4 Receiver recovery time.- The recovery time of the receiver and its associated video circuitry shall be such that the sensitivity to desired interrogations is not reduced by more than 1 dB when desired interrogations occur 8 us and more after the reception of undesired pulses having all levels up to 60 dB above the sensitivity of the receiver in the absence of such undesired pulses. The desired interrogations shall be rf pulse pairs conforming to the characteristics specified in paragraph 6-3.2.1 et seq and the undesired pulses shall conform to the same requirements except that the pulse spacing shall be outside the limits of 6-3.2.1.4 (such that dead time is not generated). The 8 us spacing shall be measured between the 50 percent voltage point on the leading edge of the second pulse of the undesired pulse pair and the corresponding point on the leading edge of the first pulse of the desired pulse pair.

6-3.4.3.5 Echo suppression.- Echo suppression shall be provided in accordance with the following subparagraphs.

6-3.4.3.5.1 Short distance echoes.- Synchronous pulse signals occurring between the constituent pulses of a direct path interrogation pulse pair and which are also superimposed on the leading or trailing edge of the second pulse of the direct path pulse pair, shall not affect the time of decoding of the direct pulse pair by an amount in excess of 0.15 us. Neither shall the reply efficiency be reduced by more than 10 percentage points from that measured in the absence of the echo pulse. These requirements shall be met when the rf input signal level of the direct path pulse pair has any level from 10 dB above threshold triggering level to an absolute level of -10 dBm and the echo pulse has any level up to the level of the direct pulse pair and for all direct pulse pair spacings of 6-3.4.3.2 (For test purposes, the echo pulse shall have a width of 8 us and need not be rf phase coherent with the direct path interrogation signal).

6-3.4.3.5.2 Long distance echoes.- A separate echo suppression circuit shall be provided in order to prevent the generation of multiple replies to aircraft interrogations having echoes which are delayed with respect to the direct path signal in excess of receiver dead time setting. The echo suppressor circuit shall be triggered by the decoding of a direct signal pulse pair whenever the level of the pulses exceeds a pre-established level. Such triggering shall result in the generation of a receiver desensitizing pulse starting at the time of pulse decoding. The degree of receiver desensitization shall be to a level of  $3.0 \pm 3$  dB above the level of the direct path signal and shall hold over the entire duration of the echo suppression pulse, unless retriggered by a signal stronger by 0 to 6 dB than the direct path signal, and over a range of input signals from 10 dB above threshold triggering level to -15 dBm. Individual controls shall be provided for:

- (a) Adjustment of the triggering level to any level between -80 dBm and -10 dBm (the latter effectively disabling the echo suppression feature). The triggering level will nominally be set at -70 dBm.
- (b) Adjustment of the duration of the desensitization over the range of 50 through 350 u seconds. The duration of desensitization will nominally be set at 150 u sec.

All settings shall be adjustable via keyboard control.

6-3.4.3.6 Station DME traffic load monitoring.- Outputs shall be provided for local and remote monitoring of:

- (a) the total number of decoded pulse pairs per second (total traffic) and,
- (b) the number of echo suppression desensitization pulses (6-3.4.3.5) triggered per second (local or strong signal traffic).

6-3.4.3.7 Receiver sensitivity.- The receiver sensitivity for a reply efficiency of 70 percent shall be in accordance with the following subparagraphs. The measurements shall be referenced to the exterior cabinet connector to which the transmission line to the antenna is connected. (The values specified shall apply in the absence of automatic gain reduction (AGR) paragraph 6-3.4.3.12.)

6-3.4.3.7.1 On-channel sensitivity.- For interrogation signals having a repetition rate of 30 pulse pairs per second and having spacings of the constituent pulses of a pair anywhere within the limits of paragraph 6-3.4.3.2 the receiver sensitivity in the absence of other interrogations, and with a dead time setting of 60  $\mu$  sec, shall be -93 dBm or better (i.e. the receiver threshold triggering level shall be -93 dBm or lower). (This value shall apply when the receiver gain control of paragraph 6-3.4.3.10 is set to allow the maximum permissible number of receiver noise decodes).

6-3.4.3.7.1.1 Variation with interrogation loading.- The sensitivity of the receiver shall not be reduced by more than 1 dB from the value measured in 6-3.4.3.7.1 above when the number of decoded interrogations is increased to as many as 2700 pulse pairs per second (2000 for "Y" Channel) with the echo suppression circuits (6-3.4.3.5.2) disabled.

6-3.4.3.7.1.2 Triggering level at other pulse spacings.- The minimum triggering level for DME signal pulses having a spacing of the constituent pulse of a pair deviating from the design center value by + 3.0  $\mu$  sec and more shall be at least 70 dB higher than the value measured in 6-3.4.3.7.1 above.

6-3.4.3.7.1.3 Desensitization by adjacent channel interrogations.- The presence of interrogation signals at  $\pm$  900 kHz from the on-channel frequencies which have pulse coding which is the same as the assigned channel (X or Y) and which occur at rates up to 1000 pulse pairs per second shall not reduce the on-channel sensitivity by more than 1 dB from the value measured in 6-3.4.3.7.1. The requirement shall be met when the adjacent channel signals have levels up to -10 dBm.

6-3.4.3.7.1.4 Desensitization by CW.- The presence of CW interference signal on the assigned channel frequency or elsewhere within the receiver pass-band shall not reduce the on-channel sensitivity by more than 2 dB from the value measured in the absence of CW interference provided that the level of the interference is no higher than 10 dB below the level of the desired on channel signal. (This requirement shall be met for all settings of the receiver squitter rate control (6-3.4.3.10) which result in receiver noise decodes at a rate of no greater than 10 per second). Additionally, within the range of receiver desensitization provided by automatic gain reduction (6-3.4.3.12) the reply efficiency to a single aircraft interrogation shall not be reduced by more than 10% when the level of the interrogation signal is 6 dB and more above the level of the interfering CW signal.

6-3.4.3.7.2 Sensitivity to adjacent channel interrogations.-The receiver shall not respond to interrogation signals at frequencies  $\pm 900$  kHz removed from the on-channel interrogation frequency and which have spacings of the constituent pulses of a pair at the design center values for the frequency in use at any level up to  $-10$  dBm.

6-3.4.3.7.3 Reply delay time variation.- (See 6.3.2.3.) Reply delay time variation shall not exceed the following:

- (a)  $+0.25$  usec over the range of service conditions with an input signal level having any value between threshold triggering level (6-3.2.7) and  $-79$  dBm with an interrogation pulse rise time of  $2.5 (\pm 0.5)$  usec.
- (b)  $\pm 0.10$  usec over the range of service conditions with an input signal level of  $-79$  dBm to  $-10$  dBm with an interrogation pulse rise time of  $0.10 (\pm 0.10)$  usec.
- (c) A total variation of  $0.10$  usec with an input signal level of minus  $(-)$   $60$  dBm with variation interrogation pulse rise time through the range of  $0.20$  usec to  $3.00$  usec.
- (d) A total variation of  $0.10$  usec with an input signal level of minus  $(-)$   $60$  dBm with variation in interrogation PRF from  $25$  through  $4800$  pulse pairs per second with an interrogation pulse rise time of  $0.10 (\pm 0.10)$  usec.

6-3.4.3.7.4 Pulse width discrimination.- The receiver shall provide a minimum of  $70$ dB of rejection to:

- (a) paired pulses of any spacing, including spacing within the range of 6-3.4.3.2, where either pulse has a width of  $0.8$  us or less.
- (b) single pulses on any width including widths within the range of pulse spacings of 6-3.4.3.2.

6-3.4.3.8 Reply efficiency.- Two sets of performance requirements are specified below. The first (paragraph 6-3.4.3.8.1) applies when the transponder is operated to provide a maximum number of replies to interrogations of  $2700 \pm 90$  pulse pairs per second. The second (paragraph 6-3.4.3.8.2) applies when the transponder is operated to permit as many as  $5000$  replies to interrogations.

6-3.4.3.8.1 Present duty cycle.- In the absence of other interrogations, the receiver and its associated video circuitry shall provide a reply efficiency of not less than 85% (80% for "Y" channel) to the interrogation of a single aircraft (30 pulse pairs per second) when the level of interrogating signal is 10 dB above the threshold sensitivity level. In the presence of additional interrogations of 2970 pulse pairs per second (3170 for "Y" Channel) having signal levels above the threshold sensitivity level, the reply efficiency to the same single aircraft interrogation shall not be less than 75% (70% for "Y" Channel) with a receiver dead time setting of 60 us and with the echo suppression circuit (6-3.4.3.5.2) disabled. (For purposes of demonstration of compliance the effect of the specified number of interrogations may be simulated through the use of one or more generators producing a total of 2500 decodes per second in the absence of other interrogations.)

6-3.4.3.8.2 Increased Traffic handling.- The requirements of 6-3.4.3.8.1 above shall apply. When the number of additional interrogations is increased to 7670 pulse pairs per second (9070 for "Y" channel) the reply efficiency shall not be less than 60% (50% for "Y" channel). (The specified number of interrogations may be simulated by 4800 decodes per second).

6-3.4.3.9 Interference suppression.- The following requirements shall be met when signals at the referenced frequencies are applied to the antenna transmission line connector at the transponder cabinet. Signals at intermediate frequencies shall be suppressed by not less than 80 dB. With the exception of the pass band provided to achieve the performance required for on-channel and adjacent channel interrogation signals and to comply with the requirements of paragraph 6-3.4.3.1, all other signals within the 960 to 1215 MHz band and at image frequencies shall be suppressed by not less than 75 db.

6-3.4.3.10 Random squitter pulses.- The video circuitry associated with the receiver shall include a separate squitter pulse generator. All squitter pulses other than those allowed hereunder to be derived from receiver noise shall be derived from the separate squitter pulse generator. Squitter pulses from the separate squitter pulse generator shall not be decoded by the interrogation signal decoder. Further, squitter pulses from the separate squitter pulse generator shall not prevent the transponder from replying to interrogation signals, providing the reply delay in "Y" channel operation is a minimum of 50.0 us. A control(s) shall be provided to permit adjustment of the number of squitter pulses derived from receiver noise.

The receiver sensitivity requirement of paragraph 6-3.4.3.7.1 shall be met when the receiver squitter rate control is adjusted to provide decoded receiver noise pulses at a rate no greater than 10 per second. It shall be possible, by setting the receiver gain control to minimum position, to reduce the receiver threshold sensitivity to -60 dBm or lower.

6-3.4.3.10.1 Priority of reply pulses.- Whenever triggers due to squitters occur prior to triggers due to decodes at the input of the priority gating circuits, the squitter triggers shall be inhibited for all spacings between triggers, of 25 us and less in "X" channel and 10 us and less in "Y" channel. The above operation applies for reply delay settings of 50 us and greater. Whenever triggers due to decodes occur prior to squitter triggers, the squitter triggers will be inhibited for all spacings of 25 us and less for "X" channel and 65 us and less for "Y" channel.

6-3.4.3.11 Pulse rate control.- The composite signal at the video output terminal of the priority gating circuitry (paragraph 6-3 4.3.10.1) shall consist of decoded interrogation pulses or squitter pulses, or both in accordance with the following and paragraph 6-3.4.3.12. The squitter pulses from the separate squitter generator shall be automatically controlled in number as a function of interrogation signal loading (6-3.4.3.11.1). The output pulse spacing distribution of the separate squitter generator shall be essentially exponential with a minimum spacing of 60 usec. When the squitter pulse generator is providing output pulses at the rate of  $2700 \pm 90$  per second (in the absence of decoded interrogation or receiver noise pulses) the output pulse spacing distribution shall be within the limits of Figure 1 (of this Part 6).

6-3.4.3.11.1 Effect of traffic loading.- For all interrogation rates resulting in zero to 2790 receiver decodes per second, the squitter pulse generator shall produce not more than  $(2790-N)$  pulses per second nor less than  $(2610-N)$  pulses per second, where N is the number of receiver decodes. For all interrogation rates resulting in excess of 2790 receiver decodes per second, the squitter pulse generator shall produce no output.

6-3.4.3.12 Automatic gain reduction (AGR).- Under interrogation overload conditions in which the number of replies to interrogation signals tends to exceed 2700 pulse pairs per second, the receiver sensitivity shall be automatically reduced by the minimum amount necessary to maintain the receiver output pulse rate of  $2700 (\pm 90)$  pulse pairs per second. The available gain reduction shall be not less than 35 dB. The AGR circuit shall be adjustable (for future use...when increased traffic handling capacity may be required) to operate at any nominal level up to a receiver output pulse rate of  $5000 \pm 150$  pulse pairs per second.

6-3 4 3.12.1 Interrogation overload signal.- At all times that AGR is in operation, a signal shall be provided to the monitor(s) (Part 7 of this specification) in order to prevent receiver sensitivity alarms at times when the sensitivity of the operation transponder has been deliberately reduced due to traffic overload.

6-3.4.4 Coder and associated circuitry.- Circuitry associated with the coder shall accomplish gating, timing and coding of the distance reply, identity, and the north and auxiliary reference burst RF output signals produced by the transmitter. The coder shall utilize the decoded reply pulse (or squitter) outputs of the receiver (6-3.4.3), north and reference burst triggers of the Reference Group Generator Module (6-3.4.6 when installed), Morse Code keying from the operating VOR transmitter or from the DME keyer (6-3.4.5) and 1350 Hz triggers from the TACAN antenna (when installed and operating).

6-3.4.4.1 Priority of transmission.- The order of precedence for transmission of the output signal pulse shall be:

- (1) north and auxiliary reference burst groups;
- (2) identity and equalizing pulse groups;
- (3) distance reply or squitter pulse pairs

Identity, equalizing, distance reply (or squitter) pulse pairs shall not be transmitted during reference groups, nor shall distance reply (or squitter) pulse pairs be transmitted during the interval (Morse code dot or dash) of transmission of identification signal pulse groups.

6-3.4.4.2 Reply Pulse coding.- Reply pulses shall be coded in pairs with a spacing as measured between the 50 percent maximum voltage amplitude point on the leading edge of the first rf pulse to the corresponding point on the leading edge of the second rf pulse, of (a) 12 (+0.25) us for channel numbers ending in the suffix "X" or, (b) 30 (+0.25) us for channel numbers ending in the suffix "Y".

6-3.4.4.3 Reply delay.- Means shall be provided to set the nominal reply reply delay time to within 0.0625 usec of any desired value between the limits of 35 to 51 usec on "X" channels (46 to 62 usec on "Y" channels).

6-3.4.4.4 Azimuth reference bursts.- The composition and duration of north and auxiliary reference bursts transmitted as a part of the transponder composite output signal (TACAN only) shall be as specified under para. 6-3.4.6. The coder shall provide priority (6-3.4.4.1) to the transmission of azimuth reference bursts whenever input is provided by the Reference Group Generator Module (6-3.4.6). Circuits utilized to provide the spacing specified for reply pulse coding (6-3.4.4.2) may also be used to generate the pulse spacings required within the azimuth reference bursts to the extent feasible.

6-3.4.4.5 Identification signal - The identification signal shall consist of a group of four pulses at a basic repetition rate of 1350 pulse pairs per second. Each group shall consist of two pairs of pulses spaced at 12 or 30 usec ("X" or "Y" channel...see 6-3.4.4.2) separated by 100  $\pm$ 10 usec (first pulse to first pulse). In the TACAN mode of operation the time of occurrence of the identification groups shall be governed by the 1350 Hz tone generator portion of the TACAN antenna. In this mode of operation, nine groups of identification signal pulses shall be provided, equally spaced, between azimuth reference bursts and synchronous therewith through common derivation from the 1350 Hz tone generator (each tenth group being suppressed as required under 6-3.4.4.1). A separate, internal 1350 Hz source shall be provided for DME operation. The internal source shall have a frequency and stability of 1350  $\pm$ 5 Hz. The internal source shall automatically assume operation at all times that the external 1350 Hz tone generator input is absent (see 6-3.4.6.5.1). The identification signal shall only be transmitted during periods of keying (Morse code dot or dash) provided by the external VOR keyer or by the internal DME/TACAN keyer (6-3.4.5).

6-3.4.5 Identification keying. Under normal operation identification keying of the DME/TACAN shall be accomplished by means of the identification keyer of the operating VOR transmitter, (See part 4 of this specification) resulting in keying of the DME/TACAN during each fourth (see 4-3.3.3.11.4.2) cycle (approximately once each 30 seconds) during which keying of the VOR is omitted. In addition thereto, each DME/TACAN transponder shall be provided its own internal keyer to permit operation of the DME/TACAN either as an independent facility or to allow the DME/TACAN to continue in operation upon failure of the VOR. In the event of shutdown of the VOR the internal keyer shall automatically assume the keying function. The internal keyer shall not operate as long as the VOR transmitter (either VOR transmitter, in a dual configuration) remains in operation or as the result of interruption of the regular cycle of keying due to transfer of VOR transmitters. Means shall be provided however for isolation of a DME/TACAN identification fault when due to malfunction of a VOR identification keyer or associated wiring and switching extend to the DME/TACAN equipment. The keying characteristics (Morse code word and character length, and repetition rate) shall be the same as for the VOR identification keyer (Part 4) except that the DME/TACAN keyer shall key each cycle.

6-3.4.6 Reference Group Generator Module.- When utilized in conjunction with north and auxiliary reference triggers and the output of a 1350 Hz tone generator provided via a TACAN antenna (Antenna not required to be furnished under this specification) the Reference Group Generator shall provide the necessary inputs to the coder (6-3.4.4) to generate north and auxiliary reference bursts in the composite output of the transponder having the following characteristics:

6-3.4.6.1 North reference group.- The north reference signal shall consist of:

- (a) a group of 12 pulse pairs having a spacing of the constituent pulses of a pair in accordance with 6-3.4.4.2 (a) and a pulse pair spacing, as measured between the 50 percent voltage amplitude points on the leading edge of the first pulse of each pair, of  $30.0 \pm 0.3$  micro-seconds for channel numbers ending in the suffix "X"; or
- (b) a group of 13 single pulses having a spacing, as measured between the 50 percent voltage amplitude points on the leading edge of consecutive pulses, of  $30.0 \pm 0.3$  micro-seconds for channel numbers ending in the suffix "Y".

6-3.4.6.2 Auxiliary reference group.- The auxiliary reference signal shall consist of:

- (a) a group of 6 pulse pairs having a spacing of the constituent pulses of a pair in accordance with 6-3.4.4.2 (a) and a pulse pair spacing, as measured between the 50 percent amplitude points on the leading edge of the first pulse of each pair, of  $24.0 \pm 0.25$  microseconds for channel numbers ending in the suffix "X"; or
- (b) a group of 13 single pulses having a spacing, as measured between the 50 percent voltage amplitude points on the leading edge of consecutive pulses, of  $15.0 \pm 0.25$  microseconds for channel numbers ending in the suffix "Y".

6-3.4.6.3 Reference group sequence and timing.- The transponder shall provide north and auxiliary reference group outputs in response to north and auxiliary trigger outputs respectively (on separate cables) provided by the TACAN antenna. Triggers are produced by the mechanical rotation of the antenna (nominally 900 RPM). One north trigger and 8 auxiliary triggers are produced during each revolution of the antenna with auxiliary triggers (approximately) uniformly spaced between north triggers. The exact time of occurrence for the start of reference bursts, and of the spacing between reference bursts is established by the output of a separate 1350 Hz tone wheel generator (90th harmonic of the antenna rotation). The Reference Group Generator shall utilize the output of the 1350 Hz tone wheel generator in conjunction with north and auxiliary triggers for gating purposes to provide north and auxiliary reference groups in the required sequence.

6-3.4.6.3.1 TACAN azimuth failure.- Automatic means shall be provided for discrimination of north and auxiliary reference input pulses in response to certain alarm action by the monitor(s) (Part 7 of this specification) resulting in the immediate cessation of transmittal of azimuth reference groups by the transmitter.

6-3.4.6.4 Reference trigger pulse characteristics.- The following defines characteristics of the (GFE) TACAN antenna trigger pulses.

6-3.4.6.4.1 Waveform and amplitude.- The amplitude of trigger pulses will be  $17.5 \pm 3.5$  volts peak-to-peak with the positive excursion occurring first and with positive and negative excursions equal within 25%. The pulse width as measured from positive peak to negative peak is 100, (-20, +0) used. In all future references the time of a pulse is measured at negative-going zero crossover. Proper termination resistance shall be 4.7 thousand ohms shunted by a capacitance of 0.01 uf.

6-3.4.6.4.2 Pulse spacing.- Adjacent trigger pulses have a spacing corresponding to  $40.0 \pm 0.1^\circ$  of antenna rotation. Additionally auxiliary reference triggers follow the north reference trigger at intervals corresponding to  $n 40.0 \pm 0.1^\circ$  of antenna rotation.

6-3.4.6.4.3 Reference pulse generator loading.- One cable (RG-62B/U) shall be provided from the TACAN antenna into the ground station equipment cabinet for each (north and auxiliary) trigger pulse input. The TACAN equipment contractor shall provide for distribution of the triggers to individual transponder(s) and monitor(s) and other units (if used). The termination impedance (6-3.4.6.4.1) shall be assumed to represent that of a dual TACAN configuration. Dummy terminations shall be provided, if necessary, for operation in the single configuration.

6-3.4.6.5 1350Hz tone wheel generator characteristics.- The 1350 Hz tone wheel generator provides an output level of 0.9 to 1.3 volts RMS when terminated in a load of 4.7 thousand ohms shunted by 0.006 uf. The amplitude is essentially sinusoidal with harmonics of the 1350 Hz fundamental (root sum squared) not exceeding 10%. The amplitude of sub-harmonics (e.g. 15 Hz due to lack of perfect circularity of the tone wheel) is 15% or less. A single cable (RG-62B/U) shall be provided from the TACAN antenna into the ground station equipment cabinet for the 1350 Hz tone. The TACAN equipment contractor shall provide for distribution of the tone to the required individual units of the transponder(s), monitors, and and other units (if used). The termination impedance stated above shall be assumed to represent that of a dual TACAN configuration. Dummy terminations shall be provided, if necessary, for operation in the single configuration.

6-3.4.6.5.1 Removal of 1350 Hz input.- Means shall be provided for automatic disconnection of the 1350 Hz tone wheel input in response to certain alarm action by the monitor(s) (Part 7 of this specification).

6-3.4.7 Transmitter and associated circuitry.- Each DME/TACAN transmitter and associated modulator and power supply circuits shall provide the following performance and output signal characteristics.

6-3.4.7.1 DME transmitter.-

6-3.4.7.1.1 Pulse shape.- The rf envelope of each pulse, as detected by a linear detector, shall have a smoothly rounded shape falling within the following limits. (These limits shall not apply to the DME transmitter when operated as a driver to the TACAN Final Amplifier 6-3.4.7.2).

6-3.4.7.1.1.1 Pulse rise time.- The rise time shall be 2.5 (+0.5, -1.0) us.

6-3.4.7.1.1.2 Pulse top.- The instantaneous amplitude of the pulse shall not, at any instant between the point on the leading edge which is 95 percent of the maximum voltage amplitude and the point on the trailing edge which is 95 percent of the maximum voltage amplitude, fall below a value which is 95 percent of the maximum voltage amplitude.

6-3.4.7.1.1.3 Pulse duration.- The pulse duration shall be 3.5 (+0.5) us.

6-3.4.7.1.1.4 Pulse decay time.- The decay time shall be 2.5 (+0.5, -1.0) us.

6-3.4.7.1.2 Power output.- The power output at the peak of each pulse shall not be less than a level of 1000 watts as measured at the output of the equipment cabinet (including losses in the transfer switch of the Facility Control and Transfer Equipment (FCT of Part 8 of this specification).

6-3.4.7.1.3 Pulse power variation.- The difference in power level at the peak of the constituent pulses of any pulse pair shall not exceed 1 dB. Additional amplitude modulation of the output pulse train shall not exceed 5 percent. (See also 6-3.4.7.2.3 for azimuth reference group droop and recovery time).

6-3.4.7.1.4 RF output control.- Means shall be provided to permit continuous adjustment of the rf output power of the transponder throughout a range of 0 to -6 dB relative to power level specified in paragraph 6-3.4.7.1.2. All transponder output signal requirements of paragraph 6-3.4.7.1.1 et seq shall be met throughout the specified range of power output levels without the need for readjustment of any other controls.

6-3.4.7.1.5 Tuning and spurious output.- The tuning of all rf stages shall be straightforward and free of ambiguities. There shall be no spurious output or parasitic oscillations in any stage for any combination of tuning control positions with either normal or subnormal excitation conditions.

6-3.4.7.1.6 RF pulse signal spectrum.- The pulse signal spectrum of the transmitter output signal shall be such that the power contained in a 0.50 MHz band centered on frequencies 0.80 MHz above and below the nominal reply frequency is in each case at a level which is not less than 47 dB below the power contained in a 0.50 MHz band centered on the nominal reply frequency. The power contained in a 0.50 MHz band centered on frequencies 2.0 MHz above and below the nominal reply frequency shall in each case be at a level which is not less than 67 dB below the power contained in a 0.50 MHz band centered on the nominal reply frequency. All other like bands of the spectrum which are further removed from the reply frequency shall have lower levels of power therein than the adjacent band nearer the reply frequency. (The above dB ratios shall apply when the transponder is delivering 1000 watts of peak power. For any higher peak power output, the minimum dB ratios shall be increased proportionately ...e.g., for an output power of 1250 watts the dB ratios shall be 48 and 68 dB in lieu of 47 dB and 67 dB. Conversely, for the reduced power levels specified in paragraph 6-3.4.7.1.4 the dB ratios shall be reduced proportionately). The foregoing requirements shall not apply to the DME transmitter when operated as a driver to the TACAN Final Amplifier (6-3.4.7.2).

6-3.4.7.1.7 Spurious output.- At all frequencies from 27 to 1660 MHz, but excluding the band of frequencies from 960 to 1215 MHz, the spurious output as measured at the antenna transmission line connector shall not exceed -40 dBm/kHz of receiver bandwidth. For purposes of determining compliance, measurement shall be made using a receiver having a 6 dB bandwidth not greater than 100 kHz.

6-3.4.7.1.8 Inter-pulse output level.- The rf output level during the interval between occurrence of the desired pulse pairs shall not exceed a level which is 80 dB below the maximum power level during the pulse. In addition, between the pulses of each pair there shall be an interval of 1.0 microsecond or greater length during which the rf output level does not exceed a level which is 50 dB below the maximum power level of each pulse.

6-3.4.7.1.9 Retriggering of transponder.- Pulse energy from a transponder shall not result in retriggering of the transponder.

6-3.4.7.1.10 Duty cycle.- The transmitter shall have a capacity for providing as many as 12,100 single pulses per second (5000 + 150 reply pulse pairs plus 900 azimuth pulse pairs when operated as a driver to the TACAN Final Amplifier).

6-3.4.7.1.11 Duty cycle overload protection. - Means shall be provided to protect equipment components against the effect of excessively high transponder output pulse rates caused by malfunction of squitter, identification, or receiver AGR circuits (6-3.4.3.12).

6-3.4.7.1.12 TACAN Final Amplifier driver application.- Means shall be provided within the DME transmitter and associated modulator circuits for the changing of output pulse levels and shapes from those required to produce the specified RF output signal characteristics to a DME antenna to those required for driving the TACAN Final Amplifier (6-3.4.7.2).

6-3.4.7.2 TACAN Final Amplifier.- The TACAN Final Amplifier and its associated power supply and modulator circuits when operated in conjunction with the DME transmitter (6-3.4.7.1) as an RF driver, shall provide all of the requirements specified for the DME transmitter except for higher power output and improved spectrum control and requirements associated with azimuth reference pulse droop and recovery time.

6-3.4.7.2.1 Power output.- The power output at the peak of each pulse shall not be less than a level of 5000 watts as measured at the output of the equipment cabinet at which connection is made to the TACAN antenna coaxial cable.

6-3.4.7.2.2 RF pulse signal spectrum.- Signal spectrum requirement shall be as stated in para. 6-3.4.7.1.6 except that each level stated therein is increased by a factor of 3 dB (e.g. 47 dB becomes 50 dB etc) and that reference to "1000 watts" is changed to 5000 watts" and reference to "1250 watts" is changed to "6000 watts".

6-3.4.7.2.3 Azimuth reference group droop and recovery time.- The average amplitude of any pulse pair within a north or auxiliary reference pulse train (or the amplitude of any single pulse in the case of "Y" channel) shall not deviate from the average peak amplitude of the pulse train by more than +2.0 percent. Additionally the recovery time following transmittal of the pulse train shall be such that the 135 Hz component of amplitude modulation shall not introduce an error of more than 0.2 degrees, for 135 Hz modulation depths by the antenna of 10.0 percent and greater. (Compliance with the azimuth error requirement may be demonstrated by calculation of the 135 Hz component by Fourier Analysis of the transponder output envelope over a period of 1/15 second).

The requirements for droop control shall be met through the use of adjustable compensating circuitry. The range of adjustment shall be adequate to minimize the amplitude of the 135 Hz component due to droop and recovery time. The system design shall consider the separate contribution of the Azimuth Reference Group Generator Module (6-3.4.6), Coder (6-3.4.4), and DME Transmitter (6-3.4.7.1), as well as the TACAN final amplifier in providing a transponder meeting these overall requirements with compensation, if necessary, provided in those circuits where most economical and effective.

6-3.4.7.2.4 RF Protection.- Adequate protection shall be provided in RF amplifiers (6-3.4.7.1 and 6-3.4.7.2) to prevent loss of active device(s) in event of failure of any other active device(s), or for any degree of mismatch (including open or short) at any point on the output transmission line.

6-3.4.7.2.5 Modular design.- In order to achieve the required power output by means of solid-state techniques, the TACAN final amplifier shall employ a number of individual RF power amplifier modules operating in active parallel (see paragraphs 1-3.2.19.3 and 1-3.2.20 of Part 1). For purposes of reliability calculation the TACAN final amplifier shall be considered to have failed when such number of individual modules has failed as to reduce the transmitter power output to a level which is at or below a level which is 3.0 dB below the initial value. Means shall be provided for maintenance monitoring of each module (see paragraph 1-3.4.4.2 of Part 1). The number of modules is not specified herein, however the equipment offeror shall propose that design which provides not only the specified reliability but which is most economically efficient in terms of initial equipment cost and life cycle cost of replacement.

#### 6-4 QUALITY ASSURANCE PROVISIONS

6-4.1 General.- See section 1-4 of Part 1 (FAA-E-2678/1).

#### 6-4.2 Design Qualification Tests.-

##### 6-4.2.1 Normal conditions.-

<u>Requirement</u>	<u>Paragraph</u>
DC input voltage	6-3.3.3
Receiver recovery time	6-3.4.3.4
Short distance echos	6-3.4.3.5.1
Desensitization by adjacent channel interrogation	6-3.4.3.7.1.3
Interference suppression	6-3.4.3.9
Squitter pulse distribution	6-3.4.3.11
Automatic Gain reduction (available gain reduction)	6-3.4.3.12
Reference pulse generator loading	6-3.4.6.4.3
1350 Hz tone wheel generator loading	6-3.4.6.5
Pulse train amplitude modulation	6-3.4.7.1.3
Tuning and spurious output	6-3.4.7.1.5
Spurious output	6-3.4.7.1.7
Inter-pulse output level	6-3.4.7.1.8
Azimuth droop and recovery time	6-3.4.7.2.3

##### 6-4.2.2 Service Conditions.-

<u>Requirement</u>	<u>Paragraph</u>
Reply delay variation	6-3.4.3.7.3(b)

In addition to the above test, one service condition test shall be conducted as in 6-4.3.2 (Type Tests, Service Conditions) with the equipment initially adjusted for operation at Increased Traffic Handling (6-3.4.7.1.10) (AGR adjusted for 5000 + 150 pulse pairs per second.

6-4.3 Type Tests6-4.3.1 Normal conditions.-

<u>Requirement</u>	<u>Paragraph</u>
Broad band operation	6-3.4.1.1
RF Tuning	6-3.4.1.2
Duplexer	6-3.4.3
Long distance echoes (range of adjustment)	6-3.4.3.5.2
Desensitization by C.W.	6-3.4.3.7.1
Reply delay variation	6-3.4.3.7.3(c) (d)
Pulse width discrimination	6-3.4.3.7.4
Reply efficiency (increased traffic handling)	6-3.4.3.8.2
Receiver sensitivity range of adjustment	6-3.4.3.10
Automatic Gain Reduction (increased traffic handling)	6-3.4.3.12

6-4.3.2 Service conditions.- The following tests shall be conducted with AGR adjusted for 2700 + 90 pulse pairs per second:

<u>Requirement</u>	<u>Paragraph</u>
Stabilization of Performance Characteristics	6-3.3.4
Frequency stability	6-3.4.3.1
DME traffic load monitoring	6-3.4.3.6
Receiver sensitivity	6-3.4.3.7.1
	6-3.4.3.7.1.1
	6-3.4.3.7.1.2
Sensitivity to adjacent channel	6-3.4.3.7.2
Reply delay variation	6-3.4.3.7.3(a)
Reply efficiency	6-3.4.3.8.1
Effect of traffic loading	6-3.4.3.11.1
AGR operation	6-3.4.3.12 and 6-3.4.3.12.1
Pulse coding tolerance	6-3.4.4.2
Identification signal	6-3.4.4.5
Identification keying	6-3.4.5
Reference burst (spacing and count)	6-3.4.6
TACAN azimuth failure	6-3.4.6.3.1
Removal of 1350 Hz input	6-3.4.6.5.1
Pulse shape (DME Transmitter)	6-3.4.7.1.1
Pulse shape (TACAN Final Amplifier)	6-3.4.7.1.1
Power output (DME Transmitter)	6-3.4.7.1.2
Pulse pair power variation (DME Transmitter)	6-3.4.7.1.3
Pulse pair power variation (TACAN Final Amplifier)	6-3.4.7.1.3
Spectrum (DME Transmitter)	6-3.4.7.1.6
TACAN final amplifier driver	6-3.4.7.1.12
Power output (TACAN Final Amplifier)	6-3.4.7.2.1
Spectrum (TACAN Final Amplifier)	6-3.4.7.2.2

6-4.4 Production tests.- Production tests shall include all test specified under 6-4.2.2 above except under normal test conditions and except for the following deletions/changes:

<u>Requirement</u>	<u>Paragraph</u>	<u>Note</u>
Frequency Accuracy	6-3.4.3.1	Stability not required
Spectrum	6-3.4.7.1.6	Delete
Spectrum	6-3.4.7.2.2	Delete

Additionally the following tests shall be conducted:

<u>Requirement</u>	<u>Paragraph</u>
Receiver dead time (range of adjustment)	6-3.4.3.3

6-4.5 Reliability Demonstration.- (See 1-4.8.1.1 of Part 1).

6-4.6 Maintainability Demonstration.- (See 1-4.8.1.2 of Part 1).

## 6-5 PREPARATION FOR DELIVERY

6-5.1 General.- (See Section 1-5 of Part 1).

## 6-6 NOTES

6-6.1 Note on information items.- The contents of this Section 6 are only for the information of the initiator of the procurement request and are not a part of the requirements of this specification. They are not contract requirements nor binding on either the Government or the contractor. In order for these terms to become a part of the resulting contract, they must be specifically incorporated in the schedule of the contract. Any reliance placed by the contractor on the information in these subparagraphs is wholly at the contractor's own risk.

6-6.2 Intended use.- See 6-1.2. This Part 6 of the specification should not be utilized for procurement of the equipment item described herein except when furnished as part of a complete set of equipment as defined in Part 1 of specification

6-6.3 (See 6-3.4.1.1.). Consideration should be given to use of two (2) (only) designs; one for low band operation (962 to 1024 MHz), and one for high band operation (1025 to 1213 MHz).

\* \* \* \* \*

FOR FIGURE 1 SEE PAGE 23.

### RANDOM PULSE DISTRIBUTION LIMITS

A MINIMUM OF 1000 READINGS OF THE SPACING OF THE 2700 RANDOM PULSES SHALL BE TAKEN. THE DATA MUST BE RECORDED TO THE NEAREST 20  $\mu$ SEC INTERVAL. COMPUTE THE RELATIVE OCCURENCE OF EACH INTERVAL -

NUMBER OF READINGS IN INTERVAL

TOTAL NUMBER OF READINGS

OF THE 50 POINTS FALLING BETWEEN 60 AND 105  $\mu$ SEC (INCLUDING ZEROS) -

AT LEAST 42 MUST FALL BETWEEN THE SOLID LINES;

3 MAY FALL BETWEEN THE UPPER DOTTED AND SOLID LINES.

3 MAY FALL BETWEEN THE LOWER DOTTED AND SOLID LINES

2 MAY FALL OUTSIDE THE DOTTED LINES.

5% OF THE TOTAL READINGS MAY FALL ABOVE 1060  $\mu$ SECS.

1% OF THE TOTAL READINGS MAY FALL BELOW 40  $\mu$ SECS.

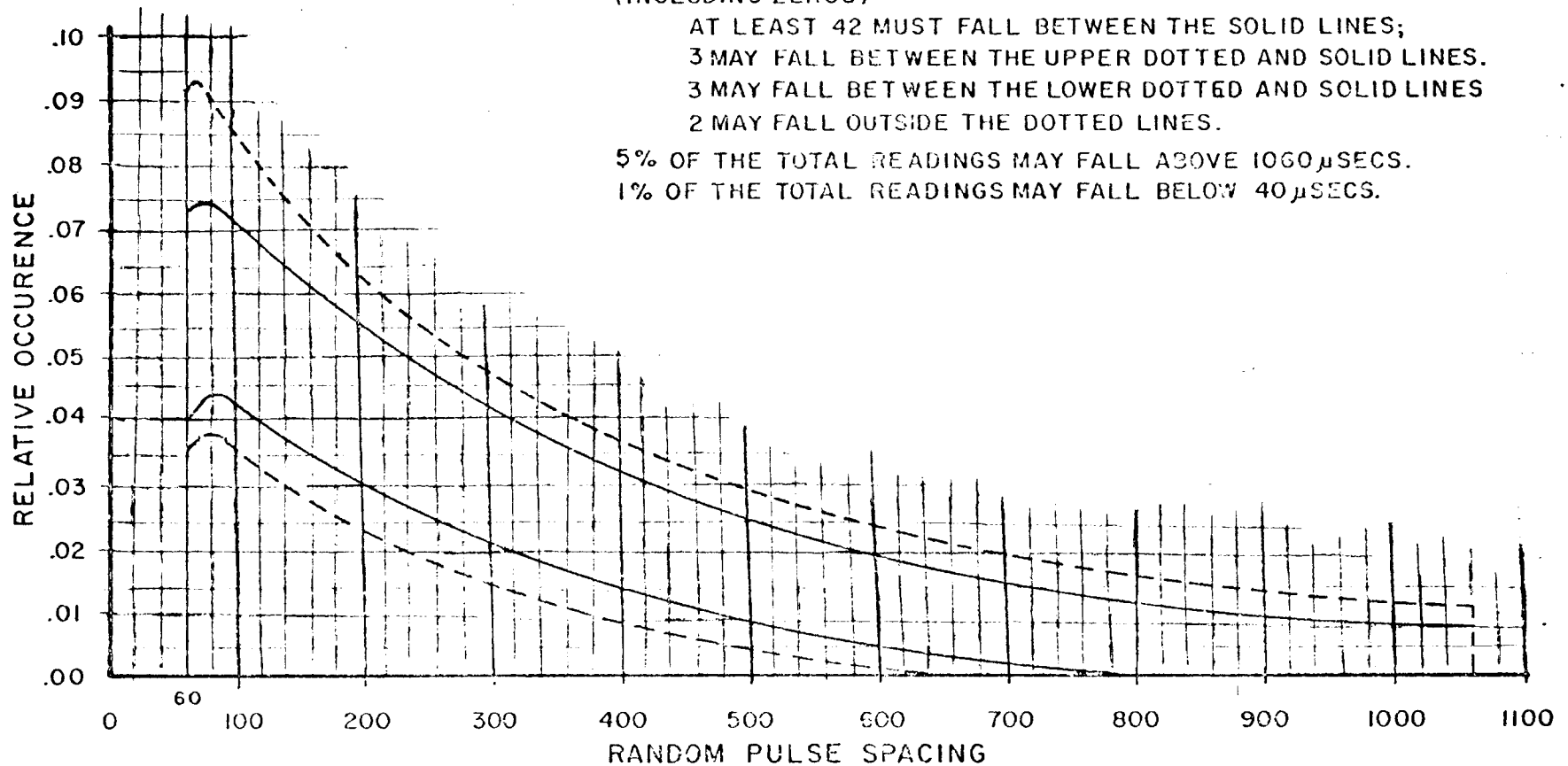


FIGURE 1.

